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THE POSSIBLE OCCURRENCE OF GAS IN THE ORISKANY SAND OF ELK COUNTY

By

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INTRODUCTION

Elk County has for many years produced oil and gas from the so-called "shallow" sands. Wells are small, rock pressure is low, and the fields may be approaching exhaustion. In 1930 gas was discovered in the Oriskany sand, a "deep" sand of this region, in Tioga County* and in 1931 in Potter County**. These discoveries have resulted in the development of two promising gas fields in which wells have an average initial volume of about 15,000,000 cubic feet a day at 1600 pounds rock pressure.

This paper is concerned principally with the possibility of finding gas in the Oriskany sand in Elk County. As the known occurrences of gas in the Oriskany seem to be closely related to domes, or structurally high points on anticlines, and no adequate structural map of Elk County was available, three weeks were spent in 1932 by M. N. Shaffner and the writer in making a structural reconnaissance examination of the county. The results of that survey and a brief resume of the stratigraphy of the county with an estimate of the depth to the Oriskany are given here.

Admittedly the results of our structural survey in this county are not satisfactory; the area does not lend itself well to reconnaissance methods. The folds that traverse the county are gentle, and usable rock exposures are few and not well distributed. A complete, dependable picture of the structure would require detailed study for which neither base maps, time, nor funds are available at this time.

RESUME OF OIL AND GAS PRODUCTION

Elk County is situated on the eastern edge of western Pennsylvania's "gas belt"***. About 25 per cent of the area of the county is classed as proven oil or gas land — a few per cent being designated as principally oil producing, the remainder as principally gas producing. Approximately 90 per cent of the proven area is in the northwestern half of the county.

The oldest field in the county, the Ridgway Field, was discovered in 1877 following closely upon the discovery of the Bradford Field, McKean County in 1875. With the exception of some gas in the Third Venango sand in the extreme southern tip of the county, production has come from the Speechley and deeper sands. Except for an occasional large gas well, the Elk County fields have not been spectacular. They have in general, however, been long-lived as is attested by the hundreds of small wells that today are still producing.

An idea of the magnitude of the oil and gas industry of the county is afforded by the following table****:

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*Pennsylvania Geol. Survey: Gas in Tioga County, Pa., Bull. 107, 1934.

**Pennsylvania Geol. Survey: Gas and Oil in Potter County, Pa., Bull. 106, 1934.

***Pennsylvania Geol. Survey: Oil and Gas Fields Map of Western Pennsylvania, 1932.

****Pennsylvania Geol. Survey: Contributions to Oil and Gas Geology of Pennsylvania, M-19, 1933, and Pennsylvania Dept. Internal Affairs, Bureau of Statistics.

Production of oil and gas in Elk County

Year	Oil			Gas	
	Barrels	Number of wells	Production per well per year	Thousands of M. cu.ft.	Number of wells
1920	-----	-----	-----	2,361	
1921	116,432	1,138	102.3	7,323	
1922	109,244	1,164	93.9	6,718	
1923	101,642	1,174	86.6	6,740	
1924	100,701	1,136	88.6	5,579	
1925	93,546	1,044	89.6	6,545	
1926	88,419	1,130	78.2	5,977	
1927	86,213	1,068	80.7	4,953	
1928	85,643	1,110	77.2		
1929	92,058	1,307	70.4		
1930	86,736	1,237	70.1		
1931	84,136	1,255	67.0	3,758	1,048
1932	81,147	1,259	64.5	2,950	1,178

In 1932 Elk County ranked 11th among the counties of Pennsylvania in oil production, the total output for the State that year being 12,208,565 barrels. In gas production, Elk County ranked 7th, the total for the State being 62,605,782,000 cubic feet.

Analysis of gas. One analysis of gas in Elk County is available to us, that of the natural gas in use at St. Marys in 1916*.

B.t.u. per cu. ft.	1,146	Total paraffin per cent . .	99.2
Sp. gr. (air = 1)	0.61	Methane	88.0
Nitrogen	0.8	Ethane etc. per cent . . .	11.2

The sample analyzed represents a composite of gas presumably from more than one field. It is not known what fields were delivering gas to St. Marys in 1916, but it is assumed that local (Elk County) gas was used.

The following table gives the average relative position and average thickness of the various sands encountered in this county. This, a composite for the entire county, is adapted from a graphic column included in Bulletin M-19** published by the Pennsylvania Geological Survey in 1933.

*U.S. Bureau of Mines, Tech. Paper 158, 1917.

**Pennsylvania Geol. Survey: Contributions to Oil and Gas Geology of Western Pennsylvania, Bull. M-19, 1933. In this bulletin average (composite) sections are given for each of the following townships in Elk County, Millstone, Spring Creek, Highland, Jones, Ridgway and Horton. All oil- and gas-producing counties of Pennsylvania are similarly treated.

Depth of oil and gas sands in Elk County from top of Hundred-foot

Name of sand	Interval in which sand may be expected	Average thickness
CATSKILL		
Hundred-foot) Venango First)	0 - 80	80
Gordon Stray	170 - 260	
Gordon) Venango Third)	300 - 360	40
Fourth	400 - 425	15
Fifth	505 - 550	40
CHEMUNG		
Bayard	665 - 700	10
Bayard Stray	740 - 750	
Elizabeth	825 - 845	
Third Warren	1,000 - 1,025	
Fifth Warren	1,280 - 1,305	
Speechley Stray	1,400 - 1,435	30
Speechley	1,520 - 1,555	25
Allegheny	1,600 - 1,620	10
Tiona	1,680 - 1,705	20
First Balltown	1,705 - 1,770	20
Second Balltown	1,805 - 1,840	30
Sheffield	1,865 - 1,915	30
First Bradford	1,930 - 1,950	20
Seoond Bradford	2,015 - 2,035	20
Third Bradford	2,115 - 2,150	25
PORTAGE		
Lewis Run	2,180 - 2,205	
First Kane	2,230 - 2,290	
Seoond Kane	2,310 - 2,340	
Third Kane	2,355 - 2,385	
First Elk	2,420 - 2,440	
Second Elk	2,505 - 2,555	
Third Elk	2,615 - 2,635	
A sand	2,785 - 2,815	
A sand	2,980 - 3,000	

The oil and gas sands of Elk County* are only provisionally correlated with the sands in the main part of the oil and gas field. All sands are represented from the Berea to the Elk group. The important-producing sands are the Speechley, Tiona, Balltown, Sheffield, First, Second and Third Bradford, First, Second and Third Kane, and the First, Second, and Third Elk.

Oil and gas fields

An adequate, systematic description of the various fields of Elk County is not available. The following notes** are included here for such usefulness as they may have.

Nansen Field (No. 1, Fig. 1) - Highland and Jones townships. Discovered 1881. Oil and gas from Bradford, Kane, and Elk sands. Initial production of early wells; gas up to 1 million cubic feet at 700 pounds rock pressure, oil 100 barrels. Present status (1930) average initial gas 40 thousand at 200 pounds. Total number wells 400 to 500.

Mill Creek Field (No. 2) - Jones Township. Discovered 1883. Gas from Tiona, Bradford, Kane, and Elk sands. Initial production (1904) 860 thousand at 625 pounds. Since 1920 wells average 50 thousand at 100 - 500 pounds. Wells long-lived.

Sackett Field (No. 3) - Highland Township. Discovered 1881. Oil and gas from Bradford, Kane, and Elk sands. Recent initial, a few barrels of oil, 100 thousand or less gas. Number of wells 400 to 500. Depth to Kane 2,500± feet.

Glenhazel Field (No. 4) - Jones Township. Discovered 1894. Oil and gas from Kane sands. Initial production of early wells, oil 3 to 4 barrels, gas less than 250 thousand cubic feet. Recent wells 2 to 3 barrels of oil, and gas small. Depth of wells 1,600± feet.

*M-19, p. 33.

**Ashley & Robinson, Oil and Gas Fields of Pennsylvania; Pennsylvania Topographic and Geologic Survey, Rept. M-1, 1920, and unpublished notes in Pennsylvania Geol. Survey files.

Bear Creek Field (No. 5) - Highland Township. Discovered 1886. Gas from Bradford and Elk sands. Initial production of early wells up to 3 million cubic feet at 850 pounds rock pressure. Recent wells less than 100 thousand at 250 pounds. Field yielded occasional large wells.

Ridgway Field (No. 6) - Ridgway Township. Discovered 1877. Gas from Speechley, Bradford, and Kane sands. Initial wells ranged from a few thousand to 8 million cubic feet at 50 to 900 pounds rock pressure. Several large wells were brought in between 1925 - 1930.

Spring Creek Field (No. 7) - Spring Creek Township. Gas from the Bradford and Kane sands. Original wells averaged 500 thousand initial. Depth of wells 2,300 - 2,550 feet.

Hallton Field (No. 8) - Millstone Township. Discovered 1888. Gas from the Speechley and Bradford sands. Initial production of early wells up to 3 million cubic feet of gas at 880 pounds rock pressure. Rock pressure now 200 pounds. Occasional good wells have been drilled in recent years.

St. Marys Field (No. 9) - Benzinger Township. Discovered 1900. Oil and gas from the Elk sands. Early wells were small and are now exhausted. Field has some 20 small wells about 1,800 feet deep.

Benezette Field (No. 10) - Benezette Township. A little gas at 376 to 720 feet.

Horton Field (No. 11) - Horton Township. Discovered 1925. Eight wells. Maximum initial 17½ million cubic feet.

Boon Mountain Field (No. 12) - Horton Township. Gas from Third Venango or Gordon Stray sand. Original wells averaged 500 thousand cubic feet initial at 100 to 500 pounds rock pressure. Average depth of wells 1,400 feet.

RELATION BETWEEN GEOLOGIC STRUCTURE AND THE OCCURRENCE OF GAS*

Any consideration of the relation in Elk County between the occurrence of gas and geologic structure should distinguish between occurrence in the so-called "shallow" sands and possible occurrence in the Oriskany sand. By studying the oil and gas fields map of the county, Fig. 1, we get a general picture of that relationship for the "shallow" sands. A statement of the relation likely to obtain in the Oriskany sand necessarily is hypothetical, but predictions can be base upon acceptable data.

Structure appears to have played a minor part in determining where gas could accumulate in the shallow sands. The only domed area that may have been directly responsible for the location of a gas field is the dome on the Hebron anticline in southern Ridgway Township on which is located the Horton Field consisting of three detached pools. Even here, production is not closely related to the dome for the several pools occur on one or both sides of the axis, extend for varying distances down the flank of the fold and in general suggest that sand conditions as well as structure have influenced their localization.

The Ridgway, Bear Creek, Spring Creek, and Hallton fields constitute a large connected area that spans the Johnson Run syncline and the Smethport anticline and production on the anticline appears to be independent of closure. Glenhazel Field, which in part is oil-producing territory, is situated well down the flank of Hebron anticline near the center of the Johnson Run syncline. Mill Creek, Nansen, and Saokett fields form a continuous area that overlaps the Smethport axis and extends far down the supposed monoclinal dip of the Smethport north flank, oil occurring along the western edge of this area. St. Marys oil field is located near the center of the Shawmut-St. Marys synoline. Boon Mountain Field

*A fuller discussion is given in Bull. 108.

spans the Sabinsville axis in a manner suggesting that it may be related to a domed area. We cannot say now whether it is or not.

In brief, anticlinal highs appear to have played little or no part in determining the location of the "shallow sand" fields; sand conditions appear to have been the dominant factor.

It has been fairly well demonstrated in Tioga and Potter counties that when gas occurs in the Oriskany sand it is found only on high points or domes on the anticlines and that it may not extend far from the high points. It therefore becomes highly desirable in any attempt to prospect for gas in the Oriskany to locate a test well as high on structure as possible.

The apparent difference in "habit" between the occurrence of gas in the Oriskany and in the "shallow" sands reflects a difference in the characteristics of the sands. The "shallow" sands commonly are lenticular, that is, they either lack continuity, or are not uniformly porous. As a result in the "shallow" sands the laws of accumulation that would tend to have gas occur high on structure are seriously interferred with. In them gas migrates toward a dome and goes as far as the capable sand extends. If the sand does not extend to the high point then accumulation must occur on the flank of the dome at the upper limit of the sand. The Oriskany sand by comparison with the average "shallow" sand is a continuous body and is more uniformly porous. Gas if present in a sand of this sort is relatively free to migrate to structurally high points, and in consequence to accumulate in domes on anticlines.

Although by comparison the Oriskany is continuous and uniformly porous, it is not 100 per cent continuous or uniform in its porosity. The Oriskany sand is absent locally and locally also it is so tightly cemented that it is incapable of containing gas. Followed along its outcrop the Oriskany is found to disappear locally, also the Matteson and the Franke wells in Potter County, the Presque Isle well in Erie County, and, coming closer home, the Haywood well, Hamlin Township, McKean County, and the Kane deep well in Highland Township, Elk County all are reported to have found the Oriskany absent. This cutting out of the Oriskany cannot be forecast in advance of drilling. The Matteson well referred to above was drilled on Hebron dome within 7 miles of a 16½ million cubic foot well. It will not be definitely known how persistent the Oriskany is within Elk County until test wells have been drilled.

It should be emphasized for those unacquainted with the situation that even though the existing fields in Elk County are not closely related to antiolinal highs, any fields that may be developed in the Oriskany sand are likely to show a very close relationship to anticlinal highs. Test wells to the Oriskany should therefore be carefully located on well-defined domes. But, even a well located test may fail for one of the following reasons: (a) the sand may be present and be porous but may not contain gas at the locality tested, (b) the sand may be so tightly cemented that it is incapable of containing gas, (c) the sand may be absent at a particular locality.

STRUCTURE

General features. Eight anticlines and four major synclines have been identified within the limits of the county (Fig. 1). These structures trend in general northeast, varying from N.30°E. in the northwestern part of the county to N.65°E. in the southeastern part. The folds are gentle, broad, flat-topped structures that commonly show dips of but 1° to 3° and only occasionally as much as 5°. In general, folding decreases in intensity in going from southeast to northwest until in the northwest townships the structures are an approach to the warped condition that is a structural characteristic of the plateau in western Pennsylvania.

No comprehensive measure was made of the relative amplitude of the several structures. The amplitude of the Hebron anticline at the latitude of

Johnsonburg as calculated from north flank dips is about 600 feet; of the Sabinsville, calculated from south flank dips through Brynsdale, is about 1,000 feet. None of the folds show marked asymmetry, but a slightly steepened southeast limb is locally discernable. It is probable that asymmetry decreased with decrease in intensity of folding, that is, in going from southeast to northwest. Even though the drilling depth to the Oriskany proves to be as much as 6,000 feet, it would not seem probable that the position of the trace of the surface and subsurface axes will be found to be greatly different, the difference probably being no greater than the limit of error involved in fixing the surface axis on one of these broad, flat-topped structures.

No evidence of faulting was observed in this area. It is possible that closer study will reveal slight breaks, but the characteristics of the folds deny the probable presence of notable faults. Northeast of Elk County many of the structures are broken* and almost without exception the faults are heralded to the geologist by abnormally sudden bends in the axis or by structurally excessively high areas. That these features are lacking in Elk County supports our contention that notable faulting probably does not exist here.

The structural data offered are from two sources; synclinal axes mapped by the Pennsylvania Second Geological Survey in 1881, anticlinal axes by the present Survey in 1932. The absence of topographic base maps, of readily traceable stratigraphic horizons, and the limited time available dictated the use of the strike and dip method in mapping the anticlines. These data were supplemented by aneroid elevations where practicable. For the most part the anticlinal areas are underlain by massive sandstones which do not lend themselves well to the interpretation of gentle folds. Usable outcrops are few and much of the terrane is timbered and not too easily accessible. Our results should, therefore, be accepted as reconnaissance value only.

The anticlines and synclines

The folds that have been recognized in the county, named from northwest to southeast, are as follows:**

Smethport anticline

Johnson Run (Clearmont-Oswayo) syncline (The 5th Bit. coal basin)

Hebron anticline

Shawmut-St. Marys-Norwich (Coudersport) syncline (The 4th Bit. coal basin)

Harrison anticline

Cowanesque syncline

Sabinsville anticline

Caledonia (Cameron-Pine Creek) syncline (The 3d Bit. coal basin)

Marshlands anticline

Wellsboro anticline

Sinnemahoning syncline

Chestnut Ridge (Driftwood) anticline

Northwest Elk County. In Millstone and northwest Highland townships there are very few usable rock exposures. Further, any folding present probably is very gentle and of the nature of warping. The writer felt that in mapping the Smethport anticline he was extending the use of the strike and dip method to the limit of its usefulness in this county. If other structures than those shown exist in northwest Elk County their definition, therefore, must await more detailed studies facilitated by a topographic map.

*Bull. 108.

**The regional relationship of these folds is shown on a map of northern Pennsylvania contained in Bull. 108.

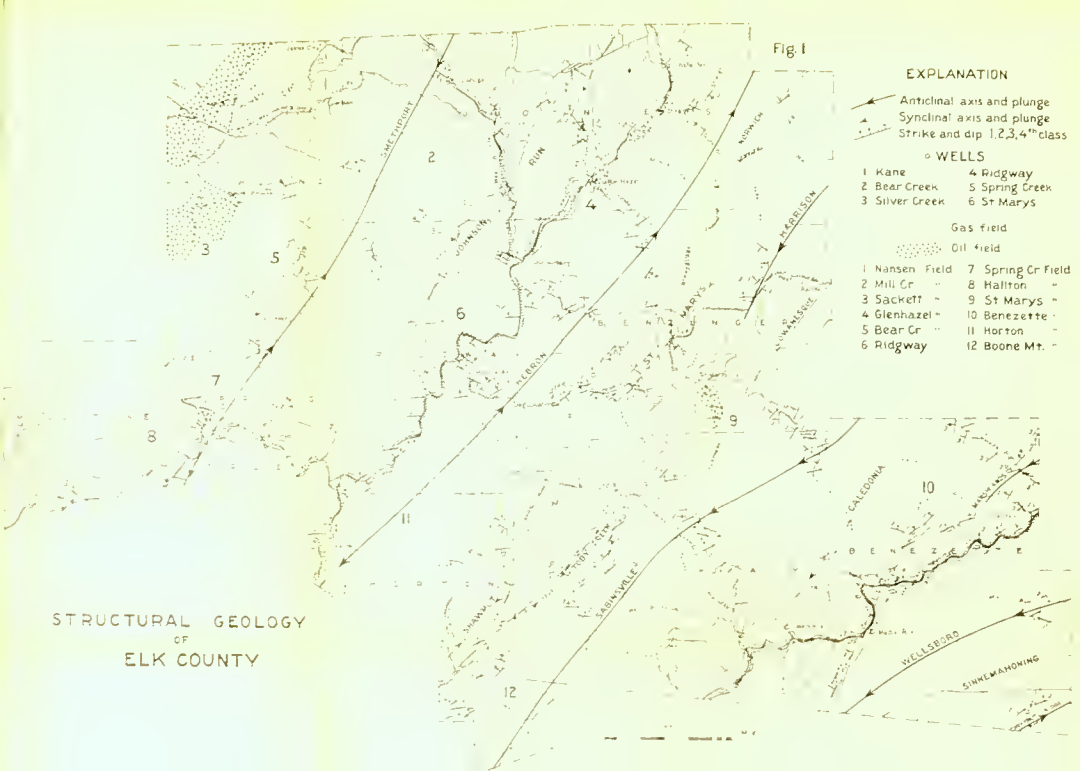
Fig. 1
EXPLANATION
Anticlinal axis and plunge
Synclinal axis and plunge
Strike and dip 1,2,3,4th class
WELLS
1 Kane
2 Bear Creek
3 Silver Creek
4 Ridgway
5 Spring Creek
6 St Marys
Gas field
Oil field
1 Nansen Field
2 Mill Cr "
3 Sackett "
4 Glenhazel "
5 Bear Cr "
6 Ridgway "
7 Spring Cr Field
8 Halliton "
9 St Marys "
10 Benezette "
11 Horton "
12 Boone Mt. "
STRUCTURAL GEOLOGY
OF
ELK COUNTY

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https://archive.org/details/possibleoccurren00cath

Smethport anticline. This anticline enters Elk County near the southwest corner of Spring Creek Township, describes an arc slightly convex to the southeast and enters McKean County about a mile east of the State Highway that joins Kane and Johnsonburg. The trend between points of entry and exit is about N.30°E. The fold continues southwest into northern Jefferson County and northeast into New York State. It is a broad, flat-topped structure that throughout most of its length in this county traverses a high, wooded country that is underlain by massive Pottsville sandstone. Where not dissected by streams the sandstone gives rise to a relatively featureless upland that is practically devoid of outcrops; where dissected by streams huge bowlders of sandstone strew the valley slopes and clutter the valley bottoms. In the valleys usable rock exposures are limited to occasional outcrops of alternating thin-bedded sandstones and shale.

The position of the axis is reasonably well controlled near the McKean County line, on Clarion River, and at a locality about midway between these points where data are available on Bear and Big Mill creeks. These limited data permit only the drawing of a smooth regular curve to depict the axial line. Owing to the probable width of the arch the axis if mapped in detail would no doubt be a more sinuous line. On a narrow, steep-limbed fold it is desirable to know the position of the axis with a fair degree of accuracy as production may not extend far from the axial area; broad folds that have gently dipping limbs, however, offer more leeway to the prospector as production may be expected to extend farther from the axis. The exact position of the axis on a fold such as this need not therefore be especially important and the interpretation pictured here may be adequate.

Neither do the data available justify too definite statement concerning symmetry, amplitude, steepness of limb and doming, but the following impressions may not be too much in error. The fold appears to be essentially symmetrical with a probable slightly steepened southeast limb. There probably is a dome in Spring Creek Township. At the McKean County line the axis has rather definite south plunge, a "low" probably existing in northwest Ridgway Township. South of this locality the axis appears to rise until just south of Clarion River where a south plunge again is discernable.

Johnson Run syncline. The Johnson Run axis plunges northward from Clarion River and probably reaches its maximum depth in Jones Township where 200 feet or more of the Allegheny coal measures have been preserved from erosion. State highway and railroad cuts between Ridgway and the McKean County line give a very fair section through the basin. Dips are gentle and notably irregular, suggesting that careful geologic work might be expected to reveal numerous minor structures of the nose and terrace sort within the basin. The probable value of such structures to those interested in Oriskany production is discussed on a later page.

Hebron anticline. Hebron anticline dies out in Jefferson County not far south of the Elk County line; it extends northeast into northern Potter County. A promising gas field in the Oriskany sand is being developed on a dome on this axis in Hebron Township, Potter County.

The surface data available offer very poor control in placing the axis of this structure in Elk County. Its position is fairly well fixed by exposures in railroad cuts on Toby Creek at the Jefferson County line, but elsewhere, due either to the absence of exposures at critical points or to the quality of the data available, the axis is fixed only in a very approximate manner.

Throughout McKean County the Hebron anticline appears to plunge south. In Benzinger Township, Elk County the axis seems to be rising to the south and the accumulated data in Horton, Spring Creek, and Ridgway townships indicate rather strongly that a high exists in southern Ridgway and northern Horton townships.

The Pennsylvania Second Survey shows this anticline as two separate structures, the one extending from southwest Horton Township to near Daguscahonda, the other from Powers Run to South Branch of Straight Creek. Many more exposures than exist would be required to say that two or more echelon axes are not present; that is especially true because the area of this fold is adjacent to the region in which warped surfaces with attendant echelon arrangement of axes is the rule.

It is in absence of adequate data to the contrary that we represent the structu in the simpler form of a continuous fold.

Shawmut-St. Marys-Norwich syncline. The work of the Second Survey demonstrated that the syncline which occurs between the Hebron and Sabinsville anticlines in this county includes several independent basins as represented on the map attached. The subsidiary basins, that in effect are but irregularities in the principal syncline, give rise to a corresponding series of upwarps or an clines; in fact the high between the Toby and Shawmut basins has been referred to in the literature as an anticline. From the standpoint of exploration of th Oriskany sand, these subsidiary anticlines probably are not important; certainl they should be ignored until the principal anticlinal highs of the region are tested, when if ever the influence of the intrabasin highs on Oriskany accumula- tion might deserve consideration. The intrabasin highs, if they could be conto ed, probably would prove to be nose-like structures extending from adjacent ant clines. The high separating the Shawmut-Toby and the St. Marys basins probably a nose that extends from the Hebron anticline, in which event any gas that may have entered the Oriskany sand at this locality would be free to travel toward dome that has been postulated as occurring on the Hebron anticline in the south part of Ridgway Township. Such migration might be interrupted and facilities f accumulation afforded by a terrace or fault at any position on this nose. The question of accumulation in a warped basin therefore becomes too complicated to deserve consideration in deep prospecting until at least the best-appearing dom on adjacent anticlines have been proved to contain gas.

The high between Shawmut and Toby basins is in the same category, as also are the terraces and noses that have been mentioned as probably existing i the Johnson Run syncline.

Harrison anticline. This structure is clearly indicated on Driftwood Branch of Sinnemahoning Creek just before it enters Elk County and it is plunging rapidly toward the southwest. It apparently dies out in eastern Benzinger Township, possibly accounting for the swell between St. Marys and Norwich basins The Harrison anticline is not known to afford any opportunity for accumulation gas in the Oriskany sand in this county.

Sabinsville anticline. The position of the Sabinsville axis is fairly well fixed on Trout Creek and on the State highway south of St. Marys. No exposures were observed in southeast Fox or southeast Horton townships, but in nor west Clearfield and adjacent Jefferson County the position of the axis is well enough determined.

From Emporium, Cameron County to the west edge of Jay Township, Elk County, the axis appears to plunge south; if any doming is present in Jay and Benezette townships it probably is slight. Between Jay Township and the Jeffers County line data are few and of poor quality owing to the terrane being chiefly a highland underlain by massive sandstone. Our data do not indicate doming in Fox and Horton townships, but they admittedly are inadequate and should be supplemented by elevations on some suitable horizon before this part of the anticli is definitely condemned.

Caledonia syncline. The dips observed in this syncline are in general steeper than those observed in the basins to the northwest. In consequence the basin, except in northeast Benzinger Township where the most southerly expressio of Marshlands anticline is seen, is simpler in its structural character than are the synclines to the northwest.

The axis plunges southwest, as a result of which some 275 feet of productive Coal Measures are preserved from erosion in Jay Township.

Marshlands anticline. This anticline is readily identified in adjacen Cameron County where it shows a strong southwest plunge. It crosses Hicks Run, Benezette Township but apparently dies out not far southwest of that point. It has no structural value in this county so far at least as Oriskany production is concerned.

Wellsboro anticline. Southeast Benezette Township is a rugged wilderness through which structure is followed with difficulty. The Wellsboro anticline can be traced with precision in Cameron County and is readily identified on Medix Run, Clearfield County, but little information concerning it is available in Benezette Township. This axis is plunging rapidly southwest on Mix Run and also on Medix Run, a few miles beyond which it dies out. In the 5-mile strip in Benezette Township for which no data are available doming may occur but the rapidity with which the structure is plunging where seen on Mix and Medix runs suggests that the presence of doming is highly improbable.

There seems to be little reason to question the interpretation given on the map attached, namely, that the Wellsboro axis is equivalent to the "Second Sub" anticline of the Pennsylvania Second Survey and is the en echelon equivalent of Chestnut Ridge anticline.*

Sinnemahoning syncline. This is a shallow basin interjacent to the Wellsboro and Chestnut Ridge anticlines throughout the distance of their overlap.

Chestnut Ridge anticline. The Chestnut Ridge or Driftwood anticline is easily identified on Mosquito Creek in the extreme southeast corner of the county. Its length within the county is only 2 miles and there is no evidence that doming exists on or near this part of the anticline. The fold dies out in Cameron County about 10 miles east of the Elk County line.

Kinzua-Emporium cross anticline*. All except one of the previously published structure maps of Elk County have shown an axis trending about N.40°W. through northeastern Jones Township, that is, about at right angles to the trend of the anticlines shown on the map attached. On regional maps this axis is extended through Cameron, Elk, McKean, and into Warren counties. This "cross axis" was described in the text of Pennsylvania Second Survey reports as a line connecting a series of domes on anticlines and saddles in synclines and was meant to show that there was a certain alignment of these "highs". Unfortunately, perhaps, the same convention was used in indicating this evidence of cross-folding as was used in indicating the anticlines proper and consequently the convention was generally misunderstood. The structure is omitted from the map accompanying this paper*.

Structurally favorable localities

The results of the Survey's reconnaissance in this area suggest that a dome occurs on the Smethport anticline in Spring Creek Township, and another on the Hebron anticline in Ridgway and Horton townships. Our data do not permit an appraisal of the Sabinsville anticline in Fox and southeast Horton townships. Careful examination may reveal other domes, and to the contrary none of the structures indicated should be accepted as proven until carefully checked by intensive methods. Certainly it is not intended here to insure the presence of closure, let alone to define the amount of closure and its exact position.

STRATIGRAPHY**

All of the rocks exposed in Elk County are sedimentary in origin. They consist chiefly of shale and sandstone with some conglomerate and a little limestone. In addition there are coal beds and an occasional bed of low-grade iron ore. The thickness of the exposed sediments ranges between 1,200 and 1,800 feet. The maximum thickness exposed in any township is 1,635 feet in the township of Benezette. The youngest rocks belong to the Conemaugh formation of Pennsylvanian age, the oldest to the Chemung formation of Devonian age.

*Bull. 108.

**Notes on the rock formations of the county, except where specific acknowledgement is made, are taken from publications of the Pennsylvania Second Geol. Survey.

Rocks exposed in Elk County

Series	Formation	Thickness feet
Recent	Alluvium	
	Unconformity	
Pennsylvanian	Conemaugh formation	65+
	Allegheny formation	214 - 327
	Pottsville formation	161 - 233
	Unconformity	
Mississippian	Mauch Chunk shale	10 - 50
	Pocono formation	500 - 610
Devonian	Catskill red beds	355 - 490
	Chemung formation	10+

Unexposed rocks

A briefed record of well #3737 of the United Natural Gas Company after C. R. Fettke's detailed log published in Bulletin Geological Society of America, vol. 44, p. 611, 1933, is given below. This well, known as the Kane deep well, i the only well to reach the Oriskany horizon in Elk County. The well is shown as location No. 1, Highland Township, on Fig. 1. The Oriskany sand is not recognize at this locality.

Geologic section in Kane deep well

Formation	Feet	Formation	Feet
Knapp (Sub-Olean)	0- 200	Middlesex black shale	142
Oswayo (Pocono?)	170	Standish shale	100
Cattaraugus (Catskill?)	327	West River black shale	219
Chemung group	2,308	Genundewa horizon ?	6
Glade sand	1,385-1,412	Genesee black shale	63
Clarendon	1,483-1,490	Tully limestone	6
Cherry Grove sand (Gartland)	1,550-1,570	Hamilton group	440
Kane sand	2,159-2,195	Onondaga limestone	82
Portage group - 1804		Helderberg limestone	20
Wiscoy shale	223	Tonoloway limestone	130
Nunda sandstone	252	Camillus formation	912
Gardeau flags and shale	438	Pittsford shale	90
Grimes sandstone	12	Lookport dolomite	320
Hatch flags and shale	130	Clinton group	176
Rhinestreet black shale	129	Medina group	166
Cashaqua shale	153	Queenston shale (T.D.)	7,242 - 7,930

Distribution of formations

Physiographically Elk County is a part of the Allegheny High Plateau*, a once extensive, almost level surface. Into this surface existing streams have cut deeply so that today their valley bottoms are as much as 1,000 feet below this old plateau surface. Viewed from a vantage point, all the high interstream "ridges" are seen to reach about the same level, that is, they represent remnants of the old plateau surface which now is so cut up by stream valleys that the county is, in effect, a mountainous country.

The streams in cutting down into the plateau have exposed successively older beds of rock. As these beds of rock are not horizontal but are folded into a series of anticlines and synclines just described, we find the youngest rocks preserved in the synclinal area and the oldest rocks exposed in the anticlinal areas. The approximate distribution of the geologic formations that are exposed at the surface is shown by Fig. 2.

Figure 2 is taken from the State Geologic Map** issued by the Pennsylvania Geological Survey in 1933 which is based upon a map issued by the Second Geological Survey of Pennsylvania in 1881. At the time the Second Survey studied this region coal was of greatest public interest and in mapping, all the coal-bearing part of the section was grouped together (convention XIII). It should be noted therefore that XIII includes not only all the Allegheny but locally the overlying Mahoning sandstone and everywhere the underlying Johnson Run sandstone and Alton shales and coal of the Pottsville formation. What is designated Lower Pottsville includes the Kinzua Creek sandstone, Marshburg coal, and Olean conglomerate.

There are no topographic or detailed geologic maps for Elk County.

The Mahoning sandstone is reported to be present only in the Shawmut-Toby and Caledonia basins. A maximum thickness of 100 feet of sandstone and shale is reported in Jay and Benezette townships, 65 feet in Horton and 55 feet in Fox townships. The principal significance of its presence is that downfolding in these basins was sufficiently deep to preserve from erosion a complete thickness of the Allegheny formation or Lower Productive Coal Measures. Allegheny and Upper Pottsville rocks occur principally in the synclines but are shown as occurring also in small isolated patches in the anticlinal areas. It is probable that most, if not all, of the Coal Measures that are represented as occurring on the anticlines belong to the Pottsville formation. Lower Pottsville rocks occur at the surface throughout about 50 per cent of the area of the county.

The distribution of the Mauch Chunk shales is not well known. Locally they appear to be absent due to erosion that preceded the deposition of the Pottsville. Where present they are but 10 to 50 feet thick and as they occur beneath the cliff-forming Olean conglomerate their outcrop not only has no lateral extent, but commonly is concealed by talus.

Pocono rocks are exposed only in stream channels or on the lower slopes of stream valleys. The total area throughout which they appear at the surface is very considerable, probably 10 to 15 per cent of the area of the county, but nowhere do the exposures have notable lateral extent. Streams are definitely known to cut through the Pocono only in eastern Benezette Township.

Exposures of Pocono are of especial interest to those concerned with oil and gas for the reason that (1) Pocono rocks are as near stratigraphically to the oil and gas horizons as we can get in most parts of this county, (2) the Pocono conglomerate is as readily distinguishable as any formation of general dis-

*Ashley, Geo. H., The Scenery of Pennsylvania, Pennsylvania Geol. Survey, Bull. G-6, p.3, Fig. 2.

**Can be obtained from Division of Documents, Department of Property and Supplies, Harrisburg, for $1.50. (Stamps not accepted.) The map shows distribution of geologic formations for all of Pennsylvania in colors. Scale 1" = 6 miles.

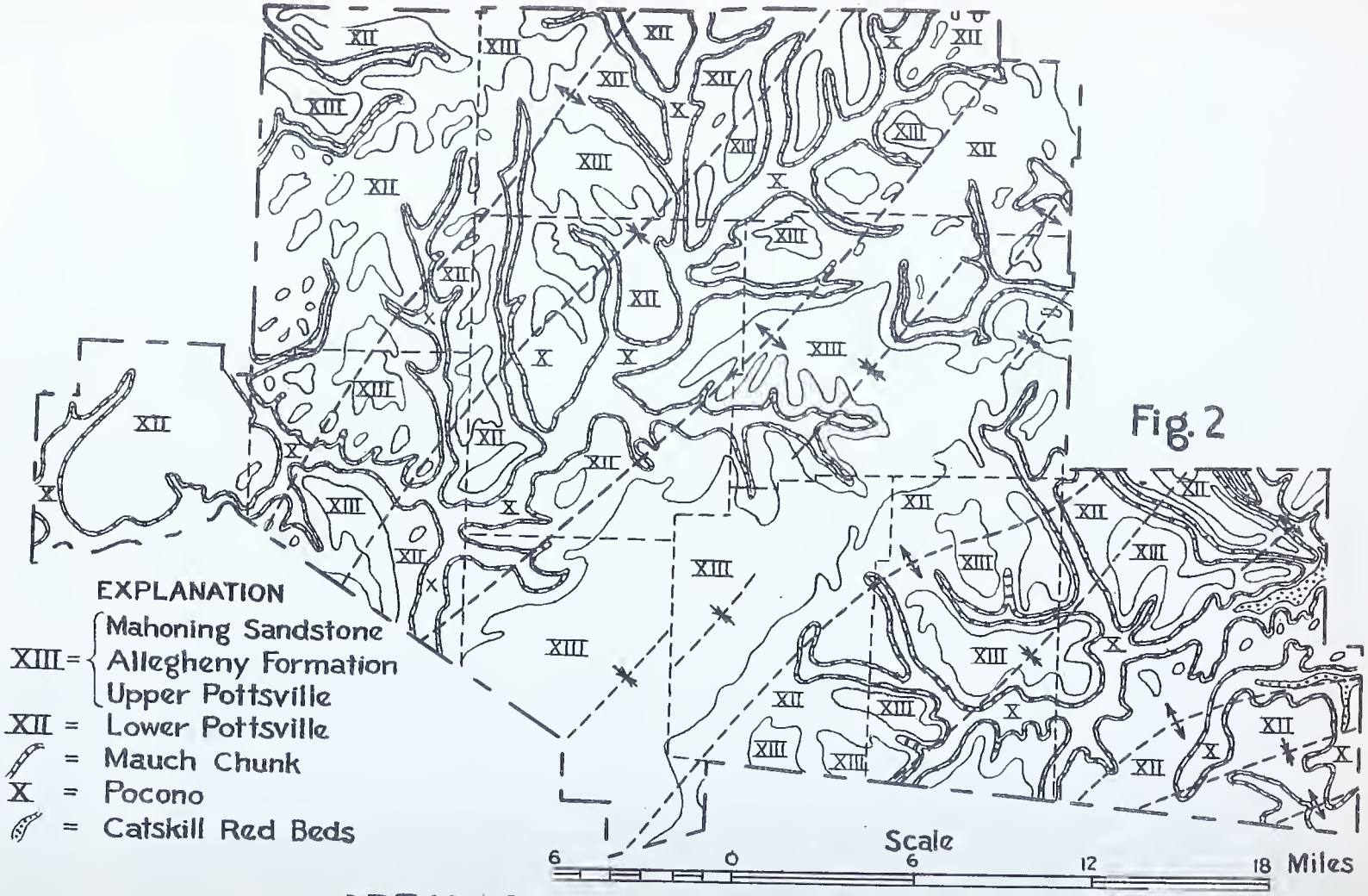


Fig. 2

AREAL GEOLOGY OF ELK COUNTY

tribution in the county, and (3) the Pocono shales and sandstones give us as usable exposures as any we encounter in the areas that are critical to the oil and gas geologist. Also, a well started in Pocono may have considerable stratigraphic advantage over a well started in Pottsville, and if it is possible to combine structural with stratigraphic advantage it is the practicable thing to do.

Catskill red beds are exposed on Bennett Branch of Sinnemahoning Creek and its tributaries in the eastern part of Benezette Township. It is reported that at one locality a complete section is represented by 490± feet of beds. Catskill beds also are reported in a small circumscribed area on North Fork of West Creek on the line of Jones and Benzinger townships, but the identity of these red beds has not definitely been proved.

Description of rock formations

Conemaugh formation. So far as known the Conemaugh is represented in this county only by the Mahoning sandstone. This sandstone in the vicinity of Kylers Corners, Fox Township, is described as consisting of greenish gray sandstone and shale and massive, coarse-grained, rather friable, very ferruginous sandstone containing flakes of mica and white and black specks. The maximum thickness observed here was 55 feet. In the Mead Run Basin, Horton Township, the Mahoning is gray and yellow flaggy sandstone and shale and the maximum thickness may equal 100 feet.

Allegheny formation. A complete section of the Allegheny formation is present in Fox and Horton townships. In Horton Township it underlies a considerable area in the Mead Run Basin and is 323 feet thick; in Fox Township the thickness is 269 feet. The Horton Township section is quoted below for reference.

Horton Township - Composite Section

	Feet
Conemaugh formation	
Mahoning sandstone	
(Sandstone and shale . 25)	
(Coal outcrop ("P vein")) . . .	65
(Sandstone and shale . 40)	
Allegheny formation	
Coal ("O vein") top bench Freeport Upper coal	3
Fire clay and shale	10
("N vein") Bottom bench Freeport Upper coal	3
Fire clay and sandstone	6
Freeport Upper limestone	2
Slaty sandstone	35
Coal ("M vein") Freeport Lower coal	3 - 4
Soft gray slates	25
Coal, cannel ("L vein")	2
Gray slate	16
Coal ("K vein")	3
Shale and sandstone	6
Freeport Lower limestone	4
Flaggy sandstone and slate, Freeport sandstone	40
Coal ("I vein") Kittanning Upper coal	3
Fire clay and slate	10
Limestone, Johnstown cement bed	5
Shale and slate	20
Coal ("H vein") Kittanning Middle coal	3
Black and gray slate	40
Coal, Kittanning Lower coal .	3
Shale and sandstone containing an occasional coal seam . .	40
Ferriferous limestone	7
Shale and sandstone	35
Coal ("C vein") Clarion coal .	3
Pottsville formation	
Johnson Run sandstone	50
Alton sandstone	
(Coal ("B vein")	
(Upper coal	2
(Slate and shale	20
(Coal ("A vein") Lower	
(coal	3
Kinzua Creek sandstone . . .	50
Marshburg shale	10
Olean sandstone and conglomerate	50
Mauch Chunk shale (red) . .	10
Pocono shales and sandstones	200+

It is possible also that a full section of the Allegheny formation is present in the Claedonia Basin. In Johnson Run Basin, Jones Township and St. Marys Basin, Benzinger Township, the Allegheny beds include only to the Upper Kittanning coal.

Pottsville formation. The Pottsville formation in Elk County ranges between 154 and 210± feet thick. Commonly it consists of five members. They are, as shown in the Horton Township section above, the Johnson Run sandstone, Alton coals and shales, Kinzua Creek sandstone, Marshburg coal and shale, and the Olean conglomerate. The variation in the thickness of these members throughout the county is tabulated on a later page.

Mr. Ashburner calls attention to the fact that the several sandstones of the Pottsville are variable in lithology when traced from one locality to another, and that this variability is likely to lead to misidentification. Further, complications are introduced by the presence of the Sub-Olean (Pocono) conglomerate a short distance below the Olean conglomerate.

In Elk County a study of the anticlines requires that the geologist work with the Pottsville and Pocono rocks and identification of these horizons therefore becomes important. From Ashburner's extensive studies in McKean, Elk, Cameron, and Forest counties he offers the following general criteria for recognition of several sandstone horizons.

The Johnson Run (Homewood) sandstone commonly consists of a rather massive, fine-grained, ferruginous sandstone containing frequent alternations of slate and shale. In thickness and character it is the most variable of any of the members of the Pottsville.

The Alton (Mercer) coal and shale member is composed principally of shale, slate, and fire clay and may contain three distinct coal beds, although rarely more than one bed is workable at any locality. Unlike the Mercer horizon of Lawrence and Mercer counties of which the Alton is the equivalent, no limestone is present. The Alton shales frequently contain scattered nodules of iron carbonate.

The Kinzua Creek sandstone represents the Connoquenessing sandstone of southwest Pennsylvania. This sandstone is very similar in its general aspect to the Johnson Run sandstone and in many localities bears a close resemblance to the Olean conglomerate. It is less massive and less ferruginous than the Johnson Run and is less conglomeratic than the Olean. It breaks up and crumbles more readily upon exposure than either of the other sandstones, a property which prevents the occurrence of bold outcrops. In general the quartz grains which make up the Kinzua are more angular and are surrounded with less cementing material than are the grains of either the Johnson Run or Olean. It differs from the Johnson Run in containing a few pebbles and from the Olean in containing very much smaller and fewer pebbles. The thickness is relatively constant. Commonly it ranges from 35 to 50 feet, but locally it exceeds 100 feet. The sandstone beds frequently alternate with shale and a sporadic coal bed, probably the equivalent of the Quakertown coal, may occur below the middle of the Kinzua horizon.

The Marshburg (Sharon) coal and shale horizon oommonly consists of 5 to 15 feet of coal, shale, and slate lying between the Kinzua Creek sandstone and the Olean conglomerate.

The Olean (Sharon) conglomerate generally consists of loosely cemented white or gray conglomerate containing spheroidal pebbles ranging in size from a pea to a goose egg; or of loosely cemented coarse-grained sandstone. One means of distinguishing the Olean from the Kinzua Creek is by the grains of quartz which are not so sharp and angular in the Olean as they are in the Kinzua. The conglomerate phase of the Olean is variable in extent and in thickness even though the thickness of the rock as a whole remains fairly uniform, that is, the pebble beds are lenticular. Locally a thin coal bed occurs immediately beneath the Olean.

The conglomerate of the Olean differs from the Sub-Olean conglomerate in the form of the pebbles contained in the two rocks. The pebbles in the upper con-

glomerate are invariably round or egg-shaped, while in the Sub-Olean the pebbles are flat or oblate spheroids, that is, have the shape of a flattened orange. The Sub-Olean too is quite different in lithologic structure. It has a tendency to break into flags, is very ferruginous, and contains iron and clay balls. No coal bed is associated with the Sub-Olean.

Mauch Chunk formation. Throughout most of the area of its occurrence in Pennsylvania the Mauch Chunk is dominantly a red formation, but in Elk County it locally does not contain red rocks. In Highland Township gray shales are reported below the Olean, in Benzinger Township west of St. Marys the Mauch Chunk is represented by 10 feet of slate carrying coal and near Scahonda by 25 to 50 feet of coal-bearing, gray shale. In Horton Township the horizon is marked by as little as 10 feet of red shale, in Jones Township by 30 to 40 feet of red shale, and in Benezette Township by 40 to 60 feet of shales and thin-bedded sandstone which locally do not contain red beds.

The Mauch Chunk is of little use to the geologist who might hope to use it as a horizon marker in mapping structure. The formation is but 10 to 50 feet thick in this region and locally appears to have been entirely removed by erosion that preceded the deposition of the Olean. Where present it occurs on a steep slope at the base of a cliff-forming sandstone and is therefore commonly concealed by talus. Although it is shown on Fig. 2 as being present everywhere, actually it was observed only occasionally.

Pocono formation. A complete section of Pocono is exposed at only a few localities in Elk County. In Benezette Township the exposed section definitely extends down into the Catskill. Other measurements of the Pocono are afforded by wells.

Ashburner for convenience divided the Pocono in this region into three members: (1) upper shales and sandstones; (2) middle sandstone and conglomerate (the Sub-Olean); (3) lower shales and sandstones. This subdivision is not entirely applicable to Elk County, however, as Mr. Ashburner states that he was unable to find the Sub-Olean southeast of a line drawn through Ridgway and the northeast corner of the county.

The upper shales and sandstones commonly consist of yellow flaggy sandstone and clayey shales. The thickness of the member varies considerably in general thinning toward the northwest.

The Sub-Olean conglomerate is the equivalent of the Shenango sandstone of Pennsylvania and of the Upper Berea sandstone of Ohio. Where present the Sub-Olean consists of a conglomerate or sandstone, sometimes one, sometimes both, sometimes alternations of each.

The conglomerate is composed of a ferruginous, open, angular, loosely-cemented, sand, containing pebbles varying in size, color, and composition, but almost invariably of a flat or oblate spheroidal form. The rock has a tendency to break into strata varying in thickness from a few inches to 2 or 3 feet. The pebbles are readily separated from their matrix and present a harder, smoother surface than those found in the Olean.

The sandstone of this member is hard, massive, fine-grained, ferruginous, and often contains iron balls. It has a tendency to break along bedding surfaces. Locally it is quite shaly and may alternate with shale.

Unlike the upper and lower members, the Sub-Olean is fairly constant in thickness. This rock can be traced along Clarion River southwest from Ridgway as far as Millstone.

In general character the lower Pocono shales and sandstone are similar to the upper member, but the sandstones are less massive, more flaggy and the alternations of shale are more frequent. Near the bottom of the member a bed of limestone occurs that appears to be widely distributed. In Jones Township on Straight Creek it consists of 4 feet of massive, blue, fossiliferous limestone at the top, 4 feet of clayey lime shale, and 1 foot of massive bastard limestone.

Here the limestone is 200 feet below the Sub-Olean. The thickness of the member is variable and decreases northwestward.

Catskill red beds. The name Catskill, as used here, refers to that part of the section immediately below the Pocono that is made up dominantly of red rocks. As the red bed series may grade into the Lower Pocono rocks above and into the Chemung rocks below the position of the top and the bottom of the unit are not definite quantities. Neither are the beds everywhere representative of the same age of deposition, for, in going eastward in Pennsylvania, red rocks occur farther and farther down into the Chemung, and in the northeast part of the State all the beds of Chemung age, and some of the underlying Portage* beds, are red. The base of the Catskill red beds can therefore be used as a stratigraphic datum only with reservations. Throughout a small area the horizon may be fairly constant in position and due to its being readily recognized may prove to be a fairly satisfactory datum, but if used throughout a large area so much error in calculations may be introduced by variation in the stratigraphic position of the bottom of the red beds that results will be seriously affected.

Several** conglomerates near the base of the red beds have been used successfully in mapping structure in this region by the method of "walking out" beds.

As the Catskill is exposed in this county only in eastern Benezette Township, we are dependent upon well records for information about it. The St. Marys well logged 335 feet of red rock; the Ridgway 334 feet of Catskill which included 6 gray sands 6 to 42 feet thick, and only 6 inches of red shell; Spring Creek well logged 335 feet of Catskill as 215 feet red sandstone at top, 35 feet of white hard sandstone, 25 feet soft shale and 60 feet red sandstone at the base; Bear Creek well logged 305 feet of Catskill as red rock with the exception of 9 feet of hard sandstone and four beds of slate 16 to 30 feet thick. These records merely suggest that in Elk County the Catskill may be expected to be 75 per cent or more red rock and that the formation is notably sandy.

It is this general horizon that in western Pennsylvania contains the Venango group of oil sands.

Chemung formation. In this formation is included most, if not all, of the producing oil and gas sands of the county. A Bradford sand is recognized here that is generally interpreted as being the approximate equivalent of the Bradford or Third Bradford sand of the Bradford Field, McKean County. For convenience Ashburner divides the Chemung into three units - (1) Upper Chemung, (2) Bradford sand, and (3) Lower Chemung.

The Chemung commonly consists of a monotonous rapid succession of gray to greenish-gray alternating sandstone and shale, interspersed with which may occur occasional thin beds of fossiliferous limestone, red sandstone or shale, and perhaps iron ore. As the Chemung is not exposed at any locality in this county any local description of it must be taken from well records.

The St. Marys well penetrated 1,050 feet of Chemung, most of which is logged as blue slate. In addition two sandstones 44 and 49 feet thick, four beds of red rock a few to 25 feet thick are recorded. Slate here probably means alternating thin beds of sandstone and shale. The Bear Creek well logged 1,079 feet of Chemung. This includes seven sands 5 to 50 feet thick, one red sand 10 feet thick, and the remainder chiefly slate.

THICKNESS OF ROCK FORMATIONS

The thickness of formations in the various townships of Elk County as determined by Ashburner is shown in the following table:

*Willard, B., Bull. Geol. Soc. Am., vol. 44, pp. 495-516, 1933.

**The Allegheny Gas Co.

Recorded thickness of formations in Elk County

Locality	Conemaugh	Allegheny	Pottsville	Mauch Chunk	Pocono	Catskill	Chemung
Jones Township*		208±	210±	45	500	50+	
Bear Creek		140	180				
Bear Creek well				45	(130 520(190 (200	304	1,079+
Benzinger Township*			400	575		25+	
St. Marys well and section		235	161(ss. 32 (sh. 24 (ss. 45 (sh. 10 (cgl.50	10±	565	335	1,050+
Ridgway Township*		141+	182(ss. 40 (sh.& (coal 22 (ss. 50 (sh.& (coal 10 (cgl.60	115+			
Ridgway well			100+	45	(U.258 625(M.138 (L.229	334	125+
Silver Creek well			154(ss. 30 (sh. 4 (ss. 35 (sh. 30 (ss. 50	45	(U. 60 520(M.295 (L.205	313	797+
Horton Township*	65+	323	185(ss. 50 (sh.& (coal 25 (ss. 50 (sh. 10 (ss. 50	10	200+		
Fox Township*	55+	214	170(ss. 50 (sh. 25 (ss. 50 (sh. 10 (ss. 50				
Jay Township*	100+	175	203(ss. 60 (sh. 28 (ss. 55 (cgl.60				
Benezette Township*	100+	175	200±	50	610	490±	10+?
Spring Creek Twp. Spring Creek well			229(ss. 55 (sh. 38 (ss.104 (sh. 2 (ss. 30	20	(U.235 670(M.185 (L.250	33 335	145+
Highland Township Kane Deep well**	Base of Catskill red beds to Oriskany 4,703 feet.						

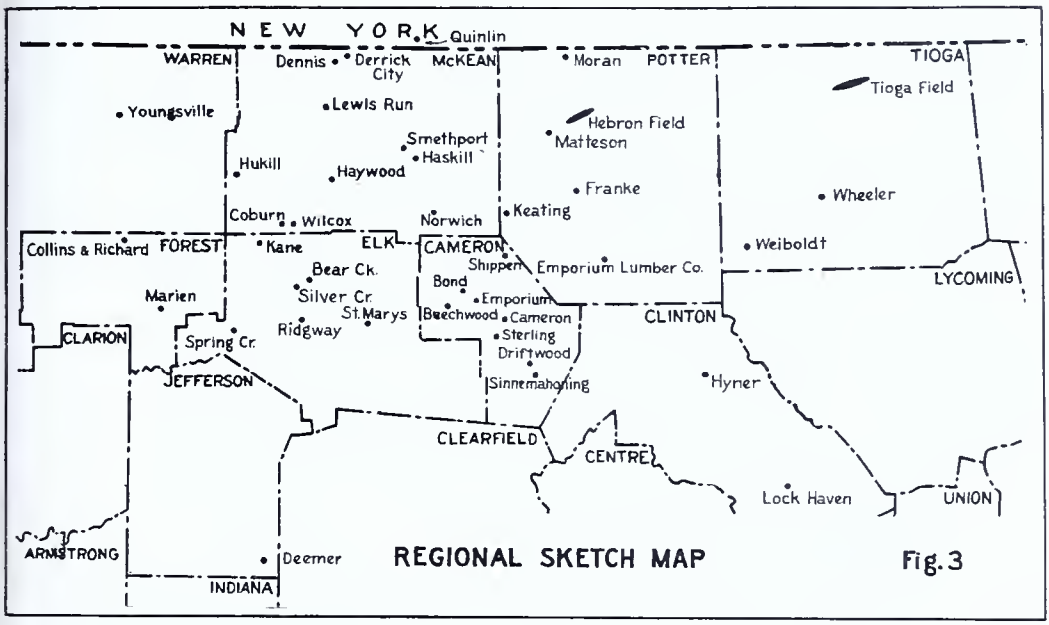
*Township composite. +Incomplete section **See log p.10.

Some Measurements of Formations
in the Clinton-Elk-Cameron-McKean-Potter County Region

Locality	Pottsville (total)	Olean conglomerate	Mauch Chunk	Pocono	Upper shale and sandstone	Sub-Olean	Lower shale and sandstone	Catskill red beds	Chemung	Upper Chemung	Bradford sand
Lock Haven section											
Clinton Co.	129		100	1175				2106			
Hyner well and section											
Clinton Co.	245			986				826	1187+		
Sinnemahoning section											
Grove Twp., Cameron Co.	115+		50	720				500+			
Driftwood section											
Gibson Twp., Cameron Co.			50	685				500+			
Sterling section											
Lumber Twp., Cameron Co.			50	660				300+			
Cameron well and section											
Lumber Twp., Cameron Co.		25+	50	548				347	510+		
Bond well and section											
Shippen Twp., Cameron Co.				410+				350	1707+		
Shippen section											
Portage Twp., Cameron Co.			30±	470				220+			
Keating Summit section											
Keating Twp., Potter Co.			20±	430				250+			
Norwich section											
Norwich Twp., McKean Co.			10±	300				140+			
Haskill well											
Keating Twp., McKean Co.		55+	0	250				250		1305	12
Smethport #1 well and sec.											
Keating Twp., McKean Co.		50+		260				250		1302	20
NW. Potter Co. section		50		400	70	60	270	370	175+		
St. Marys well											
Benzinger Twp., Elk Co.		32+	10	565				335		1050+	
Ridgway well											
Ridgway Twp., Elk Co.	100±		45	625	258	138	229	334		125+	
Spring Creek well											
Spring Creek Twp.,Elk Co.	229+	30	20±	670	235	185	250	335		145+	
Marien well											
Jenks Twp., Forest Co.	247+	70	30	537				286		222+	
Silver Creek well											
Ridgway Twp., Elk Co.	154	55	45	520	60	295	205	313		797+	
Bear Creek well											
Jones Twp., Elk Co.			45	520	130	190	200	304		1079+	
Coburn well											
Wetmore Twp., McKean Co.			0?	325	30	110	185	260±		1313	70
Wilcox well #1											
Sergeant Twp., McKean Co.				74+				260±		1290±	20+
Hukill well											
Hamilton Twp., McKean Co.		25+	0	343				260		1299	
Lewis Run section											
Lafayette Twp., McKean Co.		40	0	250	60	40	120	250		1280	10+
Dennis well and section											
Bradford Twp., McKean Co.	145	50+	0	247	60	30	157	250		1282	54

*Portage

The regional variation in thickness of the several formations is shown by the preceding figures taken from measured sections and well logs that originally were published in graphic form. Locations are shown on Fig. 3.



REGIONAL SKETCH MAP Fig. 3

These data indicate a pronounced thinning of the Catskill and Pocono formations when traced northwestward from Lock Haven into Cameron, Elk, and McKean counties. The Pocono for instance is 1,175 feet thick at Lock Haven, 986 feet at Hyner, 720 feet at Sinnemahoning, and is only 548 feet at Cameron a few miles south of Emporium. Followed north from here the formation measures 430 feet at Keating Summit, Potter County, 300 feet at Norwich, McKean County, and only 250 feet at Smethport. It has thinned a total of 925 feet in 62 miles.

Traced west from Cameron through Elk into Forest County, the following is observed. At St. Marys the thickness is 565 feet, Ridgway 625 feet, Spring Creek 670 feet, and in Jenks Township, Forest County 537 feet, but going north from Ridgway to Bradford thinning is again observed. At Ridgway 625 feet, Bear Creek 520 feet, southern Wetmore Township, McKean County 325 feet, Lewis Run 250 feet, and Bradford 247 feet.

The Catskill when traced through the same sections thins even more rapidly. At Lock Haven it is 2,106 feet, Hyner (15 miles) 826 feet and at Sinnemahoning (20 miles farther) 500+ feet, and at Cameron 347 feet. Traced northward from here it thins to 250 feet at Smethport, traced westward at St. Marys, Ridgway and Spring Creek it is 335 feet, and north of Ridgway it thins to 250 feet at Bradford.

It does not appear that drilling in Elk County will be seriously affected by the variation in thickness of these formations. Of greater concern is the thickness of the rocks between the base of the Catskill red beds and the top of the Oriskany. The few widely scattered deep wells that are tabulated below, the location of which is shown on Fig. 3, are the best guide to what we may expect this interval to be.

Wells drilled to the Oriskany horizon*

Well name	County	Elev.	Depth Orisk.	S.L. Elev.	Total depth	Results	Int. base red beds Oriskany
Palmer #1°	Tioga	1764	4006	-2242	4012	22 mil.	5000±
Wheeler, T.B.**	"	1836	5522	-3696	5663	Show gas	
Weiboldt**	"	1870	5992	-4122	6045	Dry	5709
Moran°°	Potter	2087	4875	-2788	4879	8 mil. S.W.	
Nugent°°°	"	1869	4876	-3007	4887	16½ mil.	5100±
Franke	"	2260	5864	-3604	5881	Dry, no Orisk.	
Emporium Lumb. Co.***	"	1936	6280	-4344	6425	85,000	5689
Matteson**	"	2180	5174	-2994	5550	Dry, no Orisk.	5123±
Derrick City**	McKean	1576	4135	-2559	5760	Show of oil	4268
Haywood	"	1748	5182	-3434	5269	Dry, no Orisk.	
Quinlan	N.Y. State	1686	4276	-2590	4295	Show of gas and oil	
Kane**	Elk	1836	5400	-3564	7930	Dry, no Orisk.	4703
Youngsville**	Warren	1208	3510	-2302		Dry	
Collins & Richards**	Forest	1200	4527	-3327	5252	Show gas	
Deemer**	Jefferson	1350	7235	-5885	8220	Dry	5544

°Tioga Field, Rock pressure 1665.

°°Rock pressure 1950.

°°°Rook pressure 2160 Hebron Field.

*For fuller information on deep wells in Pennsylvania and gas fields in Oriskany sand, see Pennsylvania Geol. Survey Bull. 106, Oil and Gas in Potter County, Pa., 1934; Bull. 107, Gas in Tioga County, 1934; Bull. 108, Geologic Structure in Plateaus Region of Northern Pennsylvania and its Relation to Occurrence of Gas in Oriskany sand.

**After C. R. Fettke.

***Courtesy Allegheny Gas Co.

The only well of this group that is located in Elk County is the Kane well in northeast Highland Township. The Oriskany sand is not present at this locality, but the Oriskany horizon is 4,703 feet below the base of the Catskill red beds. In Gaskill Township, Jefferson County, the interval is 5,544 feet, an in East Fork District, Potter County, 5,689 feet, at Derrick City, McKean County 4,268 feet. Apparently the interval thins in a northwest direction and in south east Elk County it may be as much as 5,500 feet. If the thinning is uniform fro southeast to northwest Elk County, we might expect the interval to be something like 5,000 to 5,200 feet in the vicinity of Ridgway. A well starting at the top the Pocono in the vicinity of Ridgway should therefore reach the Oriskany at 6,000 to 6,200 feet.

THE ORISKANY SAND

The Oriskany sand that has been recovered from productive wells in Tio and Potter counties is a fine-grained, hard, often quartzitic-appearing rock tha has an average porosity of about 9 per cent. Wells in Tioga and Hebron fields average about 15 million cubic feet a day initial. Initial rock pressure averag about 1600 pounds per square inch at Tioga and about 2100 pounds at Hebron. Initial volumes range from 1 to 70 million and rock pressure from 1450 to 2200 pounds. The capacity of the rock to hold gas at these loocalities appears to be augmented by fractures that have been partly sealed by secondary silica.

The thickness of the Oriskany varies considerably. In Tioga County it ranges from 17 to 69 feet and in Tioga Field averages 45 feet. The total thickness at Hebron Field is not known but it exceeds 12 feet. East of Hebron Field a dry hole found 10 feet of Oriskany and at the Emporium Lumber well, Potter County, Fig. 3, 31 feet is reported. In northern McKean County and adjacent New York the Derrick City well found 20 feet and the Quinlan well 18 feet of Oriskany. The Youngsville well, Warren County found 10 feet, the Collins & Richard well, Forest County, 8 feet, and the Deemer well in Jefferson County, 30 feet. Four wells in the vicinity of Matteson well and the Franke well, Potter County, did not find sand at the Oriskany horizon. The sand is absent also at Haywood well, McKean County, the Kane well, Elk County, and where the Oriskany outcrops at Lock Haven.

These data do not inform us specifically about Elk County. Whether the sand is present, how thick it is, and whether or not it carries gas can be told only by drilling.